Ollscoil na hÉireann, Gaillimh *GX____*
National University of Ireland, Galway

Semester I Examinations 2017/ 2018

Exam Code(s)	4BCT, 1MDM, 4BS
Exam(s)	B.Sc. in Computer Science & Information Technology M.A. in Digital Media B.Sc.
Module Code(s)	CT404, CT336
Module(s)	Graphics & Image Processing
Paper No.	1
Repeat Paper	
External Examiner(s)	Dr. Jacob Howe
Internal Examiner(s)	*Dr. Sam Redfern Dr. Michael Schukat

Instructions: Answer any 3 questions.
All questions carry equal marks.

Duration	2 hours
No. of Pages	5
Department(s)	Information Technology
Course Co-ordinator(s)	Dr. Des Chambers

Requirements:
MCQ
Handout
Statistical Tables
Graph Paper
Log Graph Paper
Other Material

Q.1. (Graphics)

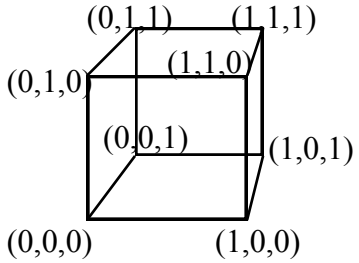
(i) Discuss the fundamental mechanisms by which modern "hardware accelerated" graphics adapters provide improved graphics capabilities. [8]

(ii) Many of the techniques used in real-time 3D graphics programming attempt to maximise the realism of the rendered scene while using a minimal number of polygons. With specific reference to this 'polygon budget', and using diagrams where appropriate, discuss each of the following four techniques:

- Back-face culling [3]
- Texture mapping and MipMapping [3]
- Bump mapping and normal mapping [3]
- Billboards [3]

Q.2. (Graphics)

(i) Presuming that the unit cube shown below is viewed using a 1-point perspective projection with the centre of projection located on the z axis at co-ordinate (0, 0, 30), calculate the (x, y) viewport (screen) co-ordinates of the 8 vertices. [8]



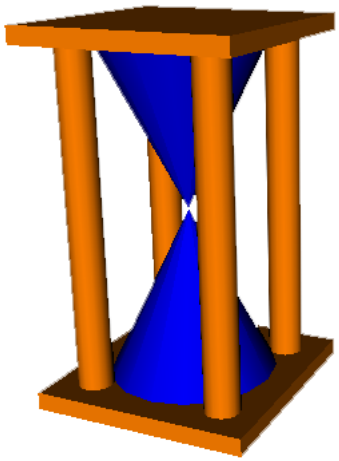
For your reference, this matrix applies1-point perspective projection where the centre of projection lies on the *z* axis at co-ordinate (0, 0, Zcp):

$$[M_{PERZ}]=\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1/z_{cp} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

(ii) Two powerful techniques for rendering shadows in realtime 3D environments are radiosity, and ambient occlusion. Explain these techniques, drawing attention to their suitability for pre-runtime computation. [6]

(iii) With respect to 3D graphics rendering, define the terms: specular colour, diffuse colour, ambient lighting. Illustrate each term with a diagram. [6]

Q.3. (Graphics)



(i) Describe the use of extrusion in X3D, referring to each of the seven fields used by the Extrusion node. Note that extrusion and other useful nodes from the X3D language are summarised on the final page of this exam paper. [5]

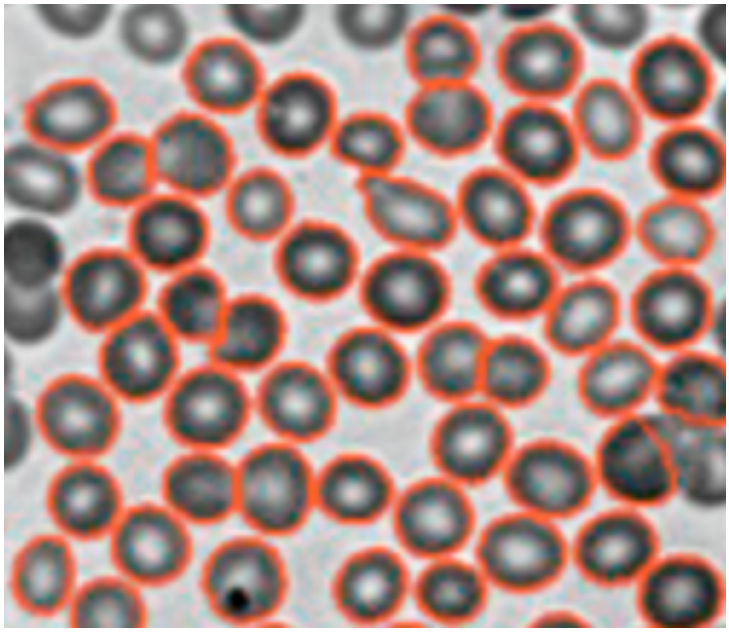
(ii) The model pictured on the right is of an egg timer. Write X3D code to create an object similar to this. You should approximate the materials as well as the geometry. [8]

(iii) Explain how you could modify this X3D code in order to animate the egg timer, so that sand appears to flow from the top cone into the bottom cone. You do not need to write out the full X3D code in your answer, however do be specific about the nodes you would use to do this. [7]

Q.4. (Image Processing)

(i) With respect to morphological image processing, outline the following operations: erosion, dilation, opening, and closing, as applied to binary images. [8]

(ii) The image below is of blood cells, and it is required that a fully automated system is developed to accurately count the number of cells in images such as this. Present a suitable and robust set of image processing algorithms for this task. Explain why each step you have chosen is appropriate. [12]



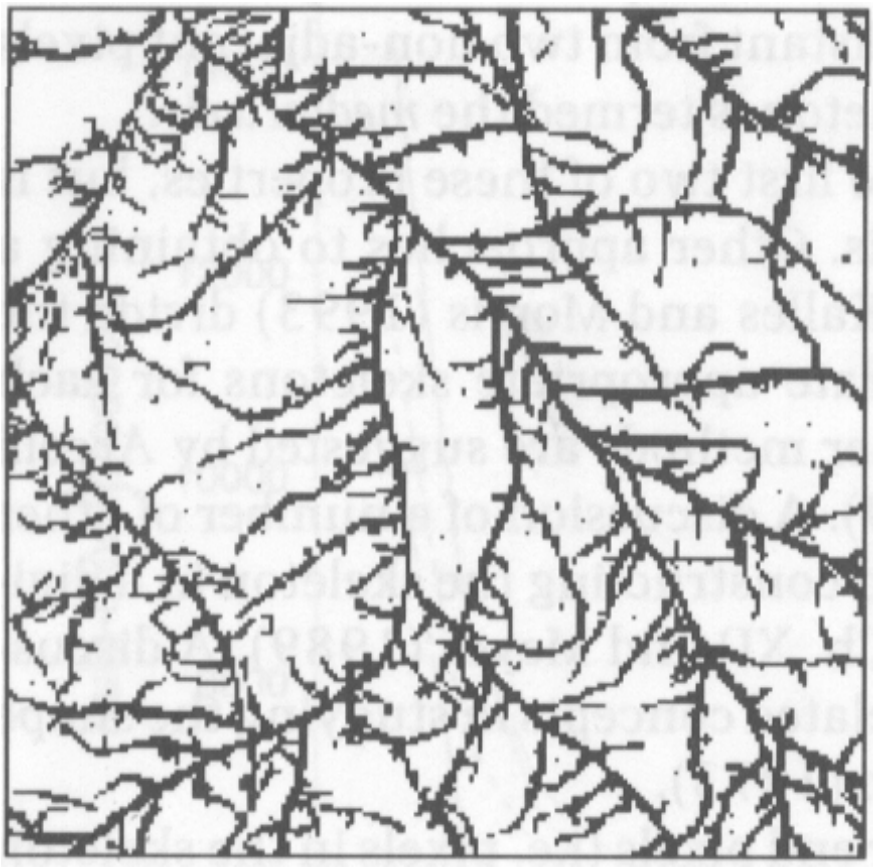
Q.5. (Image Processing)

(i) Edge Detection is an important image processing tool for identifying objects of interest in a scene. Discuss the following two edge detection techniques, indicating circumstances under which each would be useful:

- compass edge detection [4]
- boundary tracking (e.g. the Canny technique) [4]

(ii) Discuss one common approach to improving an edge-detected image, prior to segmentation and further analysis. [4]

(iii) The thresholded (i.e. binary) image below is of fungal growth in a laboratory. Presuming that the total length of growth is to be monitored over time via a series of such images, provide a suitable and robust set of algorithms for automating this task. Explain why each step you have chosen is appropriate. [8]



Some useful X3D nodes:

Node	Important Fields and Nested Nodes
Shape	Nested Nodes: Appearance, Geometry Nodes (Box, Sphere, Cone, Cylinder, Text, Extrusion, etc.)
Appearance	Nested Nodes: Material, ImageTexture
Material	Fields: diffuseColor, specularColor, emissiveColor, ambientIntensity, transparency, shininess
ImageTexture	Fields: url
Transform	Fields: translation, rotation, scale, center. Nested Nodes: Other Transforms, Shapes, Sensors
TimeSensor	Fields: enabled, startTime, stopTime, cycleInterval, loop
PositionInterpolator	Fields: key, keyValue
OrientationInterpolator	Fields: key, keyValue
Extrusion	Fields: crossSection, spine, scale, orientation, beginCap, endCap, creaseAngle
Box	Fields: size
Sphere	Fields: radius
Cylinder	Fields: radius, height, side, top, bottom
Cone	Fields: height, bottomRadius, side, bottom
PointLight	Fields: on, location, radius, intensity, ambientIntensity, color, attenuation
ROUTE	Fields: fromNode, fromField, toNode, toField

Some useful methods/properties of the Canvas 2D Context object:

Method/Property	Arguments/Values	Notes
fillRect	(Left, Top, Width, Height)	Draw a filled rectangle
beginPath	None	Start a stroked path
moveTo	(X, Y)	Move the graphics cursor
lineTo	(X, Y)	Draw a line from graphics cursor
stroke	None	End a stroked path
fillStyle	="rgb(R,G,B)"	Set fill colour
strokeStyle	="rgb(R,G,B)"	Set line colour
save	None	Save the current coordinate system
restore	None	Restore the last saved coord system
translate	(X,Y)	Translate the coordinate system
rotate	(angle)	Rotate the coordinate system clockwise, with angle in radians
scale	(X,Y)	Scale the coordinate system independently on the X and Y axes